Agilent 8510 Network Analyzer

Product Note 8510-7A

Microwave Component Measurements—
Amplitude and Phase Measurements of Frequency Translation Devices Using the Agilent 8510C Network Analyzer

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Introduction

The capability to measure the amplitude and phase match between frequency translation devices (FTDs), such as mixers, is increasing in importance as the number of multi-channel signal processing systems increases. These multi-channel systems, such as direction-finding radars, require that the signal transmission through each channel be amplitude and phase matched. To achieve the required match between channels, the manufacturer usually constructs each channel with matched sets of components.

The match between FTDs is defined as the absolute difference in amplitude and/or phase response over a specified frequency range. Also, the tracking between FTDs is an important specification. The tracking between FTDs is essentially how well the devices are matched over a specified interval after the removal of any fixed offset. For example, this interval may be a frequency interval or a temperature interval, or a combination of both.

Traditionally, the measurement of amplitude and phase match between FTDs has been hampered by the need for an external computer to control the frequencies of two sources and a measuring receiver. The 8510C network analyzer, with its multiple source feature, may be configured to directly and independently control two sources as well as its own receiver. This configuration allows for fast and versatile measurements of FTDs without the need for an external controller. Specifically, the 8510C with the 8511A frequency converter is well suited to take amplitude and phase matching measurements of FTDs.

Figure 1 shows a typical test setup for measuring the amplitude and phase match between mixers. This setup is capable of measuring fixed or swept IF signals from 45 MHz to 20.0 GHz and supplying RF and LO signals from 10 MHz to 20 GHz. The range of the RF and/or LO signals may be extended into millimeter-wave frequency bands by the addition of the appropriate millimeter-wave source module(s) available from Agilient Technologies.

This note describes the basic test setup, measurement procedure, and expected performance of the 8510C when applied to the measurement of amplitude and phase match between frequency translation devices. Also, this note describes how to measure input impedance and port to port isolation of FTDs using the 8510C.

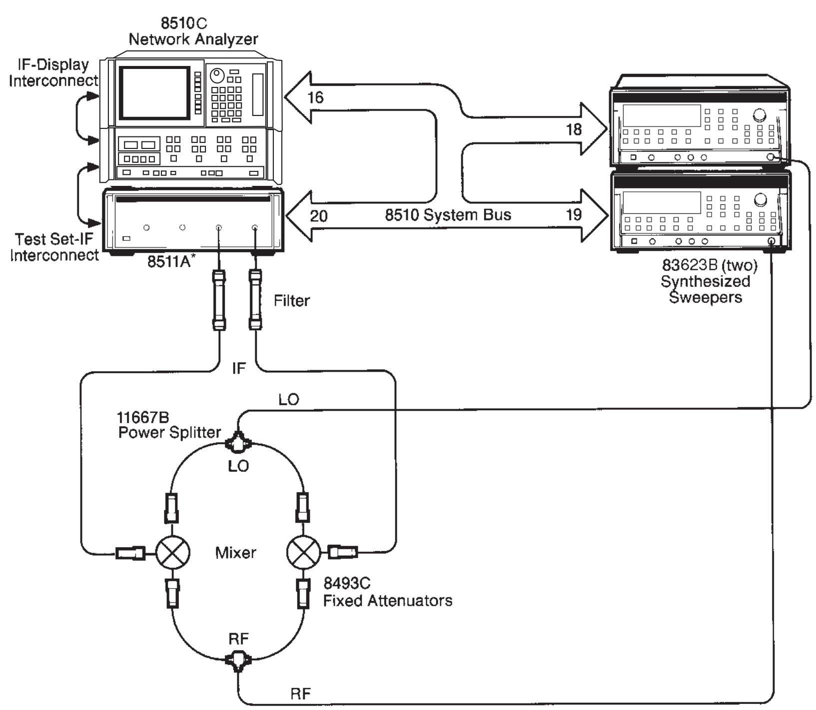


Figure 1. 8510C mixer test system

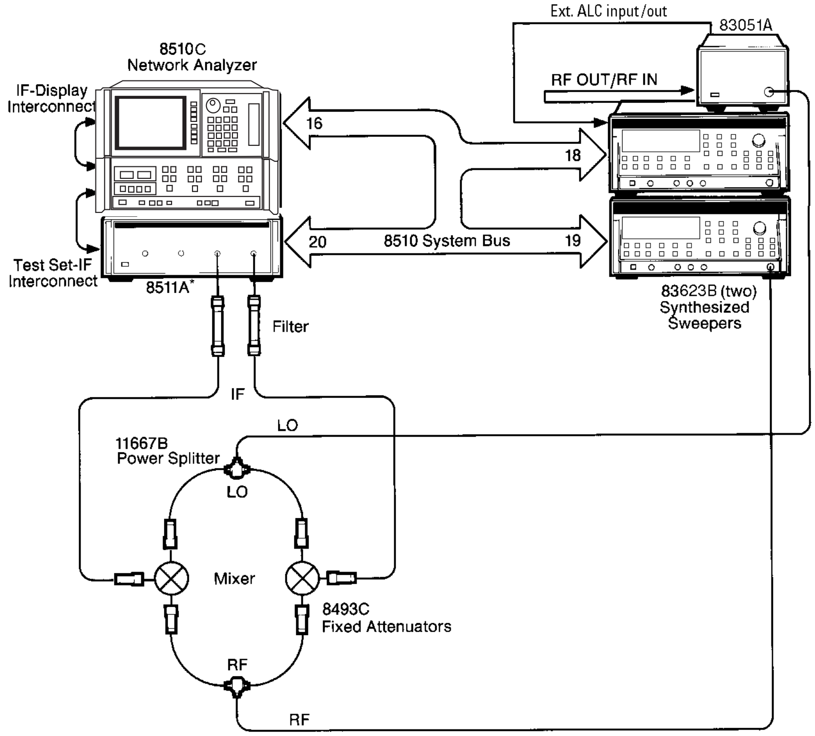
System description and installation

Figure 2 shows a detailed block diagram of the 8510C-based system shown in *Figure 1*. The complete measurement system consists of an 8510C network analyzer, an 8511A frequency converter, any combination of two 83623B or two 83624B synthesized sweepers.

Also shown in *Figure 2* is a detailed block diagram of a test fixture used to aid in the measurement of the amplitude and phase match between mixers. This mixer test fixture consists of two 11667B power splitters, six 8493C fixed attenuators (four 6dB and two 10db), various semi-rigid coax cables, and two filters to eliminate spurious mixing products from entering the 8511A. In this case, two 1.5 GHz low-pass filters are used. (The exact function of this mixer test fixture will be discussed later.)

The instruments should be connected to the 8510C system bus, and interconnected with BNC and interface cables as show in *Figure 2*. Once the 8510C system has been configured as described above, it may be turned on. At this point, the 8510C sweep mode should be set to STEP sweep via the STIMULUS MENU softkeys. Also, it is important to make sure that the instrument GP-IB addresses are set correctly. The multiple source mode of operation may now be accessed to directly and independently control the two sources and the 8511A receiver.

Note that after the system has been turned on, and prior to the activation of multiple source mode, a "CAUTION: NO IF FOUND" or "CAUTION: PHASE LOCK FAILURE" message may appear on the 8510C display and a warning beeper may sound – do not be alarmed. Realize that not until multiple source mode is activated, and the 8511A receives a signal that it can phase-lock to, will the error message cease. In the meantime, the beeper may be turned off via the BEEPER OFF softkey which is located under the 8510C SYSTEM key.



Model Number	Comment	GPIB Address
8510C		16
8511A/B*		20
83623B 83624B 83630B 83650B	RF source normal power is ok	19
83623B 83624B 83630B* 83650B*	LO source must be high power	18
LO amp. 83051A* for LO's above 20 GHz	Rear panel in front out	N/A

* Note: An 8511B can also be used, but as you go above 20 GHz an appropriate higher frequency RF and LO will have to be used with the appropriate 83051A amplifier with 12V bias, for 83620, 30, 50B's. LO sources are to low in power to drive the LO, so the mixer will get into it's linear operating range.

Figure 2. Multiple source mode configuration with mixer test fixture and a list of reccommended instruments.

Multiple source operation

Accessing multiple source mode

The multiple source mode of operation and the multiple source definition menu may be accessed through the EDIT MULT. SRC. softkey which is located under the SYSTEM key of the 8510C. *Figure 3* shows the multiple source definition section and how to access it through various 8510C menus. Also shown in *Figure 3* are the multiple source definitions used for the measurement shown in *Figure 1*.

Defining the source/receiver frequencies

As show in *Figure 3*, the operating frequencies of each of the two sources and the 8511A receiver may be defined as a function of the DUT frequency specification (FREQ). FREQ is entered in the conventional way by use of the START/STOP-NUMBER OF POINTS method, the FREQUENCY LIST method, or the SINGLE POINT method.

The SOURCE 1 and SOURCE 2 frequencies may be defined as a fraction, or a multiple, of FREQ and an offset frequency. The multiplier, whether a fraction or a multiple, must be a positive ratio of integers, such as 1/3, 1, 2, or 5/2. The frequency offset may be negative as long as the resultant frequencies, defined by the equation, are positive and fall within the limits of the source. The SOURCE 1 and SOURCE 2 frequencies may also be defined to be constant (or CW) frequencies.

The 8511A (or other test set) measurement frequencies may be defined in the same fashion as the source frequencies, with the added flexibility that the multiplier may be a positive, or a negative, ratio of integers. Again, the resultant measurement frequencies, as defined by the equation, must be positive and fall within the limits of the 8511A frequency converter.

For the case shown in *Figure 3*, FREQ is defined to be a 201 point, stepped-sweep from 2-20 GHz SOURCE 1 (the RF source) is defined to step from 2.0-20.0 GHz. SOURCE 2 (the LO source) is defined to step from 1.8-19.8 GHz, or 200 MHz below the RF source. The 8511A RECEIVER (the IF receiver) is defined to measure the fixed IF or 200 MHz at each of the 201 measurement points.

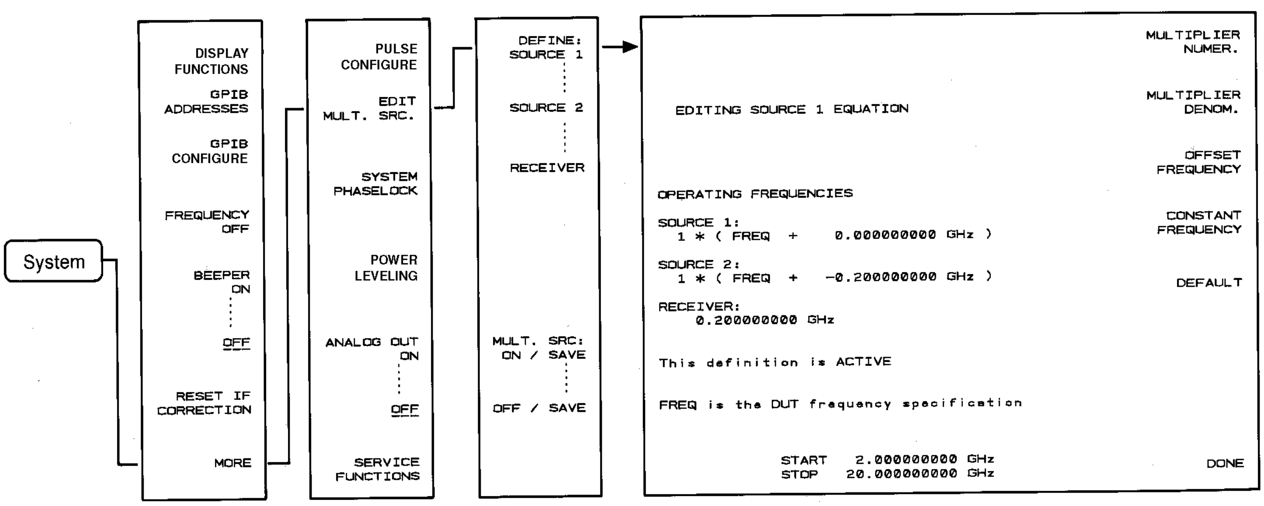


Figure 3. Multiple source access path and source/receiver definition menu.

Defining the source/receiver frequencies (continued)

As another example, *Figure 4* shows the multiple source definitions used for two different swept IF mixer measurements. Both measurements use a fixed LO (SOURCE 2) of 18 GHz. In one case, the LO is a "low-side" LO. In the other case, it is a "high-side" LO. Notice that in one case the IF steps up in frequency, while in the other case the IF steps down.

After the multiple source definitions have been completed, multiple source mode may be activated via the MULT. SRC: ON/SAVE softkey. (When multiple source mode is active, the letter "M" appears in the enhancement label area of the 8510C display). The MULT. SRC: (ON/OFF) / SAVE softkey serve the dual purpose of turning on/off multiple source mode and saving the multiple source definitions in the 8510C hardware state.

Adjusting the output power of both sources

The output power of each source may be controlled directly from the 8510C front panel via the POWER MENU softkeys in the STIMULUS MENU section. Once the source output powers have been set to their desired levels and the multiple source mode has been activated, the mixer (or other FTD) measurement procedure may commence.

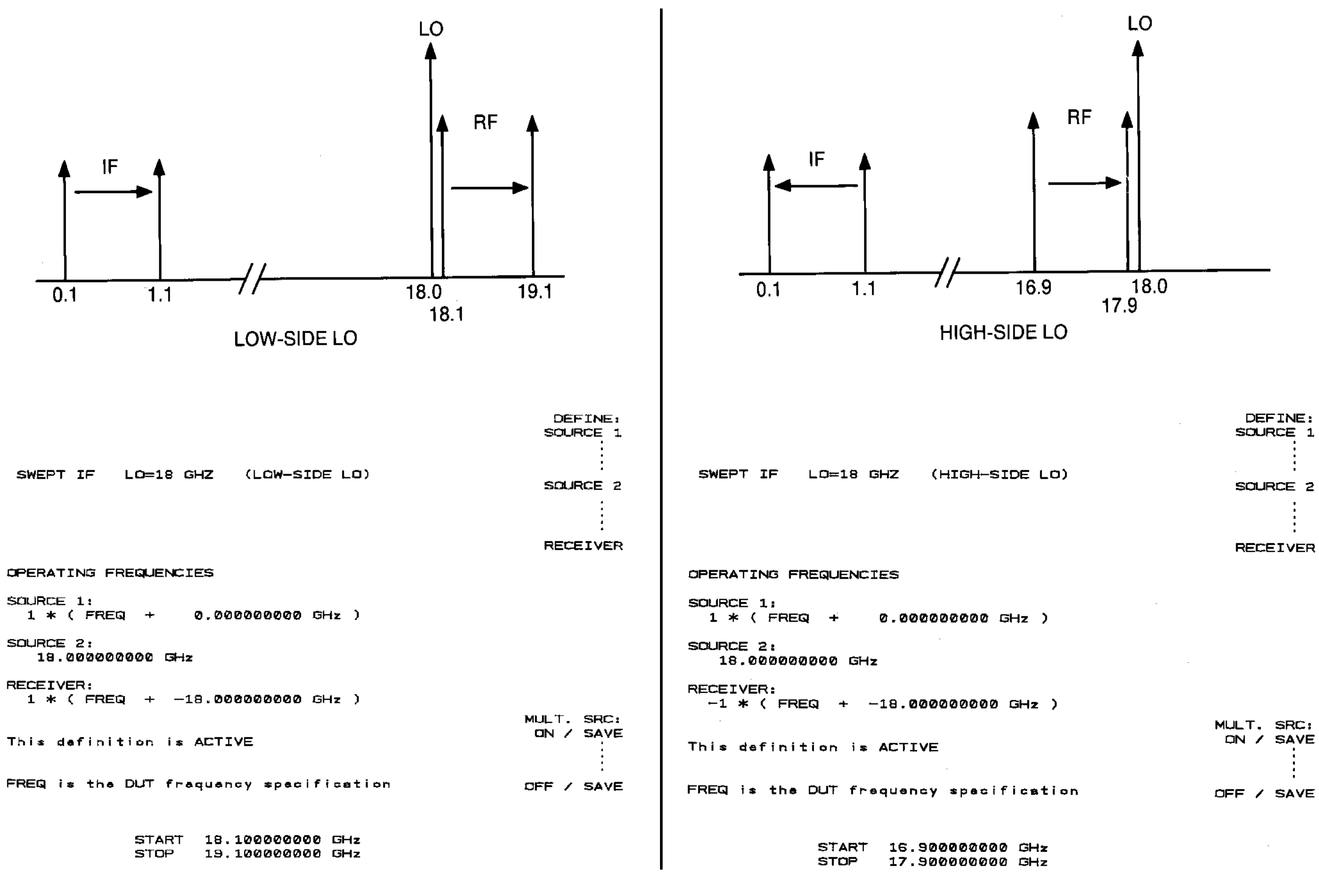


Figure 4. Source/receiver definitions for swept IF measurements using low-side and high-side LO.

The hardware state

The 8510C hardware state contains the multiple source definitions and their on/off status, the GP-IB addresses of the system instruments, and the system phase-lock status. For instance, the hardware state of the system shown in *Figure 1 and 2* contains the multiple source definitions shown in *Figure 3*, the GP-IB addresses shown in *Figure 2*, and a system phase-lock status set to internal phase-lock. This hardware state is a user-defined description of how the 8510C-based system is configured, and unlike the instrument state, it is not subject to change when the PRESET key is pressed or when the system is powered up.

Hardware states may be stored and loaded from the 8510C internal disc via the softkey menus located under the key. The ability to store and load hardware states from disc allows for the fast reconfiguration of the 8510C from one measurement application to another. For example, a single 8510C-based system may be quickly changed from a mixer test system to an antenna or millimeter-wave device measurement system simply by configuring the necessary instruments (hardware) and loading a previously stored hardware state.

The newly loaded hardware state contains the GP-IB addresses, system phase-lock status, and multiple source definitions necessary for the system to function properly. (After the hardware state is loaded, multiple source mode will automatically be turned on or off depending on the state in which it was saved).

Once the appropriate hardware state has been loaded, various instrument states, calibration sets, etc. may also be loaded from disc to complete the instrument set up. For example, consider the case where a group of three users wants to use an 8510C for taking mixer measurements, and another group of five users wants to use the same 8510C to measure devices using TRL and/or noninsertable calibration methods. To compound the matter, the users within each group have different measurement parameters such as frequency span, cal kit type, etc. To solve this matter, each group uses its own hardware state stored on a disc, and the individual users within each group use their own instrument state, cal kit, etc., stored on disc as well. By loading the appropriate hardware state, instrument state, etc., these users save valuable setup time and possibly the cost of another system.

Amplitude & phase matching of mixers

In the case of mixers and other FTD components, a test figure similar to the one shown in *Figures 1 and 2* is necessary to measure the amplitude and phase match between individual components. A block diagram of the test fixture with two mixers in place (mixers A & B) is shown in *Figure 5*. For the example shown in *Figure 5*, multiple source mode is activated with the source/receiver frequency definitions shown in *Figure 3*.

The measurement procedure consists of first measuring the ratio of the two channels (User3=b2/a2) and storing that ratio in display memory. Next, one of the two original mixers (preferably the b2-channel mixer, mixer B) is replaced by a third mixer (mixer C), and the ratio of the two channels is taken again. This ratio is compared to the ratio in memory by use of the DATA/MEM display function. This display of DATA/MEM is the amplitude and phase match between the third mixer and the original mixer it replaced (mixer C/ mixer B).

This procedure may be continued indefinitely, comparing many mixers (mixers C, D, etc.) to the original mixer (mixer B) and thus indirectly comparing them all to each other. By using all eight of the 8510C display memories in the manner mentioned above, it is possible to directly compare any mixer to eight other mixers (one stored in each memory 1-8) with only one connection.

The fundamental principle behind this measurement procedure lies in the fact that the only thing that has changed as one mixer is replaced by another, is the response of the mixer. Since the rest of the test fixture has not changed, what is measured is the difference between the mixers. This normalization procedure removes the effects of the power splitters, 8511A/B channels, and the rest of the mixer test fixture from the measurement. Notice that mixer A is not compared to the other mixers, it serves as a measurement and phase-lock reference only.

When comparing several mixers, it is good measurement procedure to periodically reinsert the original mixer (mixer B) and observe the display of DATA/MEM. This display of DATA/MEM should be flat as shown in step 1 of *Figure 5*. This procedure will verify that the measurement system has not changed with time, and that the comparison of each mixer is as good as the first comparison.

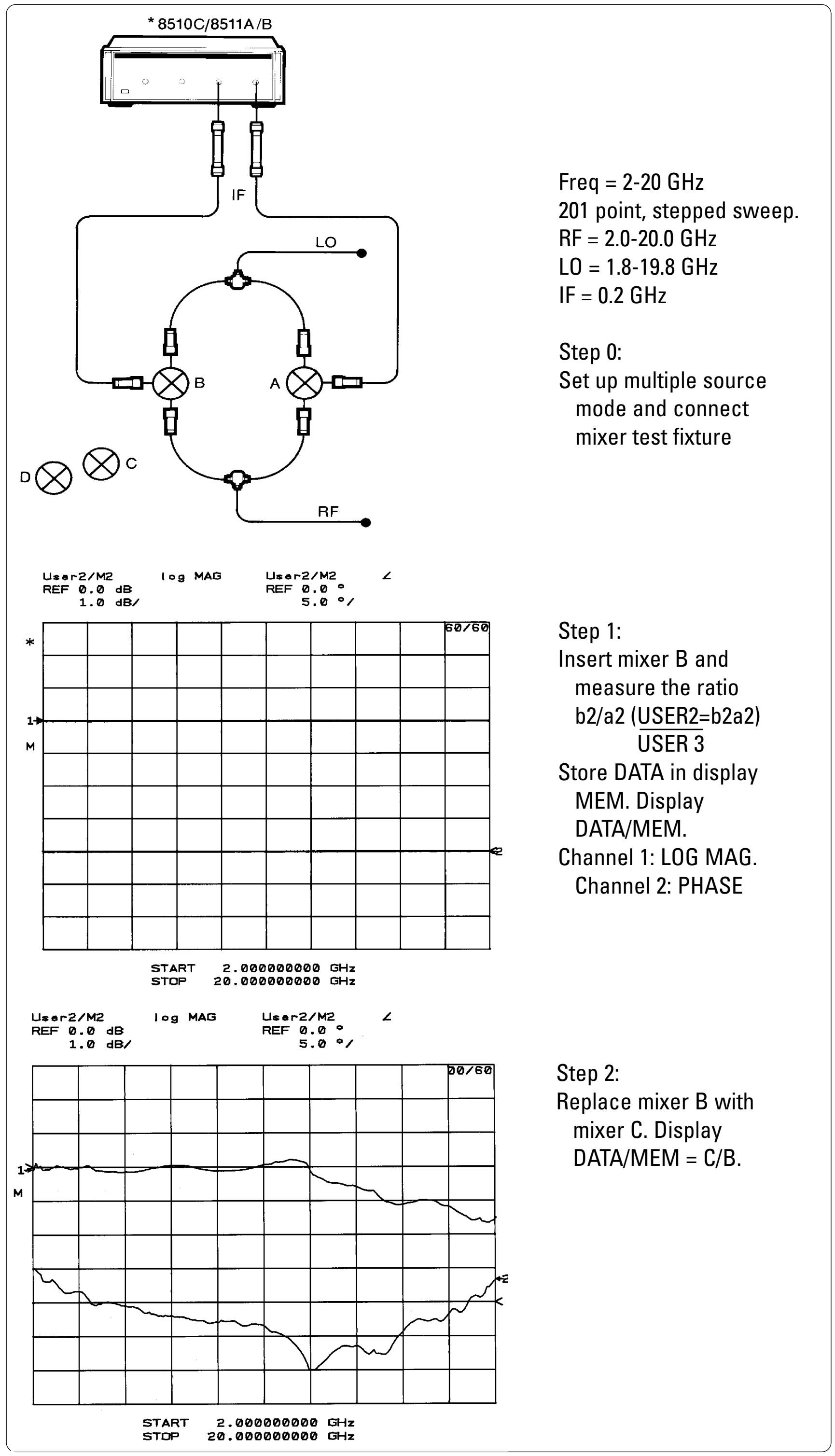


Figure 5.

*** 8510C is not shown for simplicity**

Accuracy considerations

There are three principal sources of measurement inaccuracy associated with the mixer measurement system described above. These three sources of error are nonideal system port matches, crosstalk from one channel of the test fixture to the other, and spurious responses caused by unwanted mixing products which enter the 8511A/B.

Because the measurements are not corrected for source and load match, it is necessary to pad all of the mixer ports. This will reduce the measurement errors associated with the interaction between the mixer port matches and the system port matches. To reduce crosstalk between channels, it is important to use two-resistor power splitters such as the 11667B rather than three-resistor power dividers. Also, because the 8511A/B is a sampler-based receiver, care must be taken to insure that spurious mixing products do not interfere with the measurement. For the case shown in *Figure 5*, a 1.5 GHz LPF was used to eliminate the spurs. For further discussion on the topic of identifying and reducing the effect of spurs on the measurement results, see Appendix A.

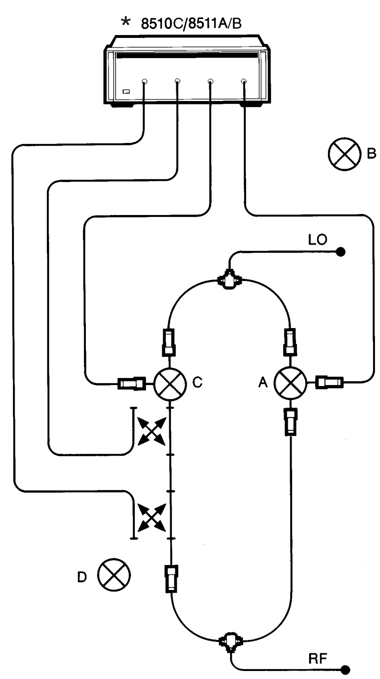


Figure 6. Mixer amplitude & phase matching fixture with RF VSWR and RF-IF isolation measurement capability.

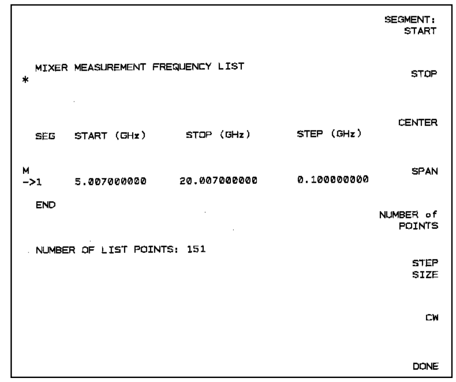
Measuring mixer input impedance and port to port isolation

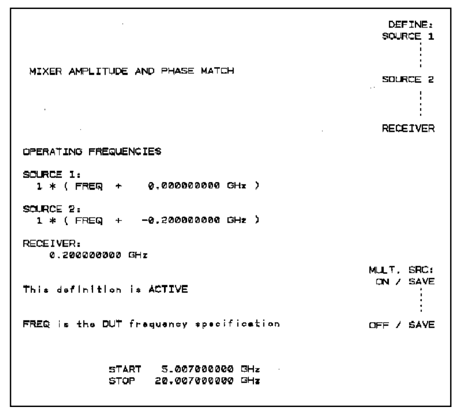
As shown in *Figure 6*, a reflectometer may be included in the mixer test fixture. This configuration allows for measuring the amplitude and phase match between mixers, the RF input impedance, and the RF port to IF port isolation of each mixer with only one insertion of the mixer into the mixer test fixture. Notice that the IF filters shown in *Figure 5* are not present in *Figure 6*. The filters are not present so that the RF to IF isolation may be measured. If the measurement of the RF to IF isolation is not necessary, then the filters do not need to be removed. (Even with IF filters to eliminate spurs from the amplitude and phase matching measurement, spurs may still occur in the measurements of the RF input impedance).

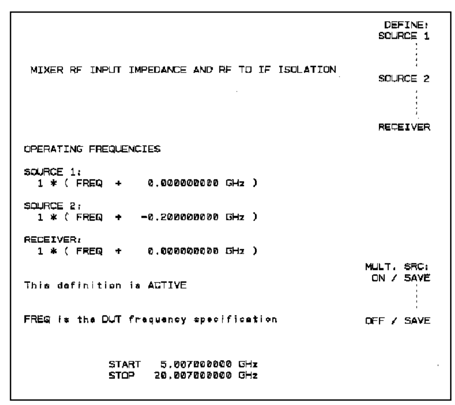
To eliminate spurious responses in all three of the measurements described above, the 8510C frequency list mode is used to select measurement frequencies at which no spurs occur. Shown in *Figure 6* is the frequency list used for all three measurements. This simple frequency list was generated with the aid of the spur analysis program described in Appendix A. (In general, a frequency list may consist of up to thirty-one segments with any number of points per segment, as long as the sum of all points is not greater than 801).

Notice that although the frequency list if the same for all three measurements, the multiple source definition is not the same. (Frequency list defines FREQ which is used in the multiple source definitions). For measuring the amplitude and phase match between mixers, the RECEIVER is defined to measure the constant IF of 200 MHz. For measuring the RF input impedance and the RF to IF isolation, the RECEIVER is defined to measure the RF signal.

Using the frequency list shown below and the appropriate multiple source definition, the amplitude and phase match between mixers is measured as described in *Figure 5*; the result is shown in Figure 6. At this point the “amplitude and phase matching” hardware and instrument states are saved on disc.







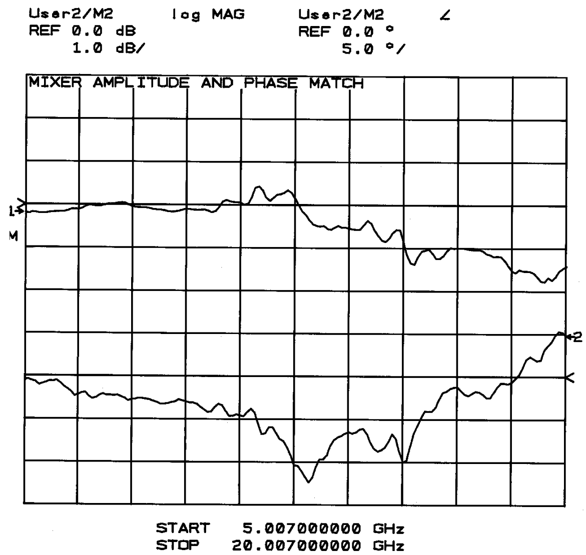
*** 8510C is not shown for simplicity**

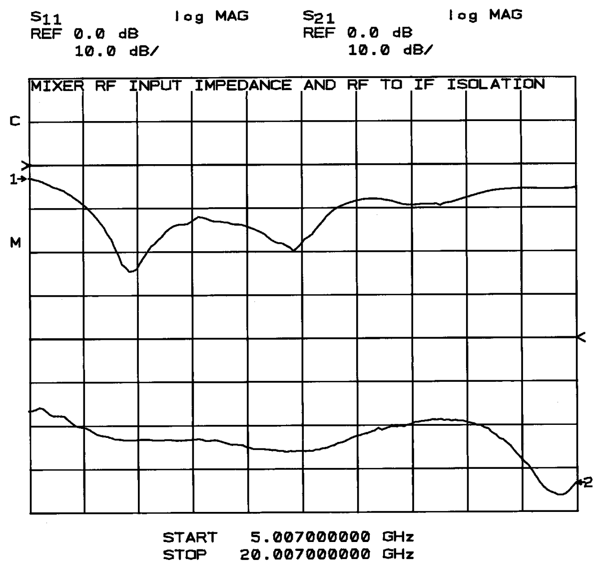
Measuring mixer input impedance and port to port isolation (continued)

Next, the multiple source definition is changed to accommodate the measure-ment of the RF input impedance and RF to IF isolation. Then, an S11 1-port calibration and an S21 thru response calibration are performed and saved to provide error corrected measurements of the RF input impedance and the RF to IF isolation. The multiple source definition and the measurement results are shown in Figure 6. Finally, the "RF input impedance/RF to IF isolation" hardware and instrument states are saved on the same disc as the "amplitude and phase matching" hardware and instrument states.

This measurement system and procedure allows for measuring amplitude and phase matching, RF input impedance, and RF to IF isolation of mixers simply by inserting the mixer and recalling the appropriate hardware and instrument states.

When the amplitude and phase match between mixers is not important, or when spur avoidance becomes difficult, the measurement system show in *Figure 7* may be used to measure the RF and LO input impedance, the LO to RF isolation, and the RF to LO isolation separately from the amplitude and phase match.





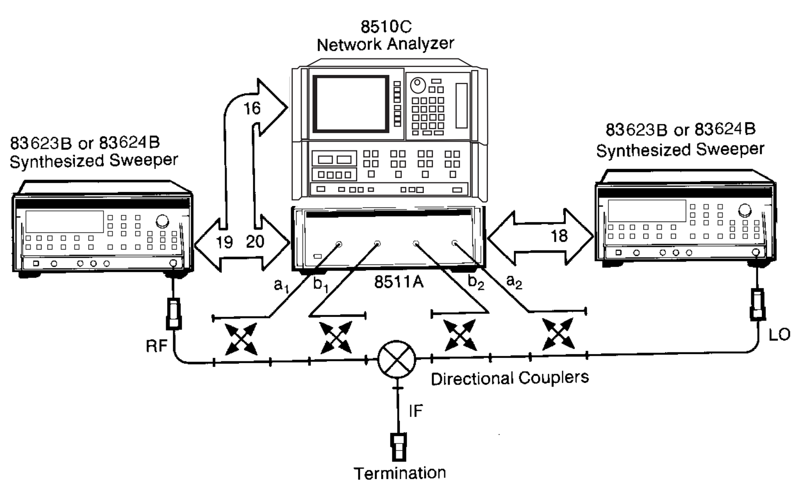


Figure 7. Mixer input impedance and isolation measurement system.

Note: Please see Figure 2 for suggestions on how to go above 20 GHz using 8511B and the appropriate RF and LO source and LO source amplifier.

Amplitude & phase matching of receiver channels

In the case of amplitude and phase matching between channels of a multi-channel receiver, it is often necessary to measure all of the channels simultaneously. In this case the method used to measure the amplitude and phase match between individual components such as mixers, one at a time, will not work. Some other method must be used to eliminate the effects of any external power splitters and the 8511A/B frequency converter.

For example, consider the measurement block diagram in the dual-channel receiver shown in *Figure 8*. The measurement system is the standard system as described in *Figure 2* (without the mixer test fixture). Multiple source mode is used to supply the dual-channel receiver under test with RF and LO signals, and also to measure its IF output signals.

In this example, the source/receiver frequencies are defined as shown in *Figure 9*. The RF (SOURCE 1) and LO (SOURCE 2) sources are defined to step-sweep (201 points) from 9.7-9.9 GHz and from 9.4-9.6 GHz respectively. The 8511A/B frequency converter is defined to measure a constant IF of 300 MHz at each measurement point of the 201 point stepped-sweep.

Normalizing the Test Setup

To accurately measure the amplitude and/or phase match between the receiver channels, the difference in frequency response between the RF power splitter arms and between the 8511A/B channels must be removed. (The effect of the LO power splitter should not be removed because it is internal to the dual-channel receiver).

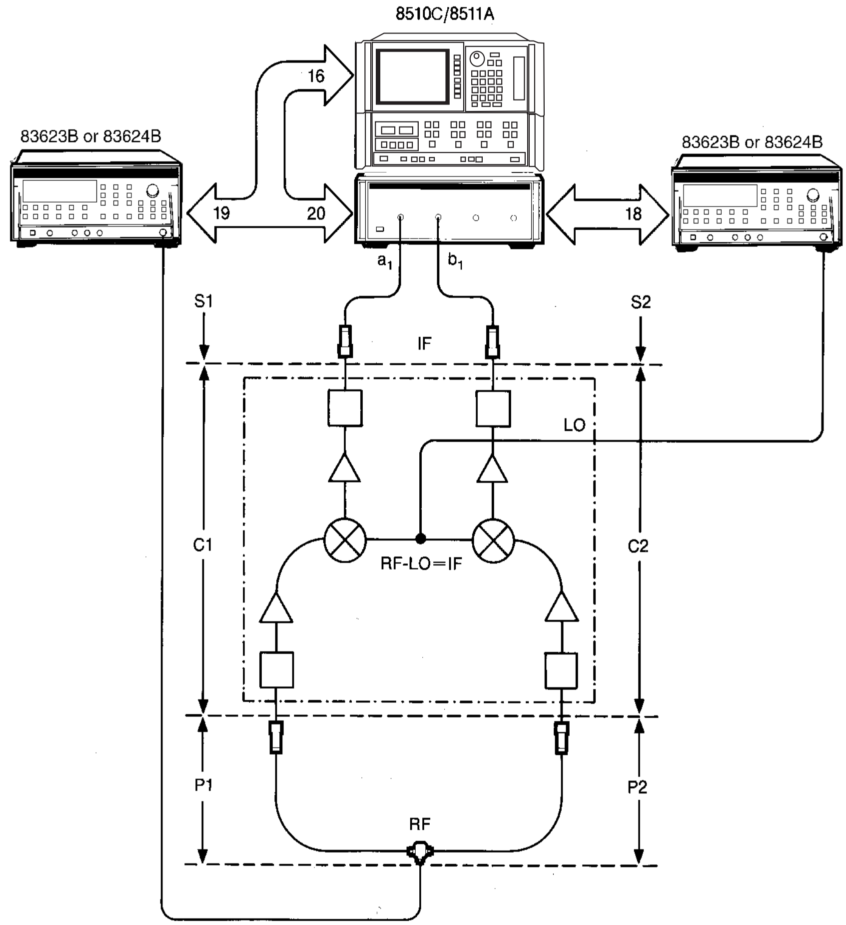


Figure 8. Dual-channel receiver measurement system block diagram.

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201 POINT STEP SWEEP

OPERATING FREQUENCIES

SOURCE 1:
  1 * ( FREQ  +     0.000000000 GHz )

SOURCE 2:
  1 * ( FREQ  +   -0.300000000 GHz )

RECEIVER:
    0.300000000 GHz

This definition is ACTIVE

FREQ is the DUT frequency specification

              START   9.700000000 GHz
              STOP    9.900000000 GHz
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Figure 9. Multiple source mode frequency definitions for measurement of dual-channel receiver.

Measurement of the RF power splitter

The normalization procedure begins by measuring the difference in S21 between the arms (P1 & P2) of the RF power splitter over the RF span (9.7-9.9 GHz, 201 points). As shown in Figure 10, these measurements are best made with an 8510C and 8515A (or other S-parameter test set) based system using full 2-port error correction. Multiple source mode is not active at this time.

First, P1 is measured and the result is stored in the 8510C display memory. Then, P2 is measured and DATA/MEM is displayed. The result of these measurements (P2/P1, amplitude and phase) is transferred to an external computer and stored on a disc (See Appendix B for the computer program used during this procedure).

As shown in *Figure 10*, the RF power splitter may actually consist of a power splitter, some fixed attenuator, and various coaxial cables or waveguide sections for interfacing to the RF inputs of the dual-channel receiver. All of these components must be included in the measurement of (P2/P1).

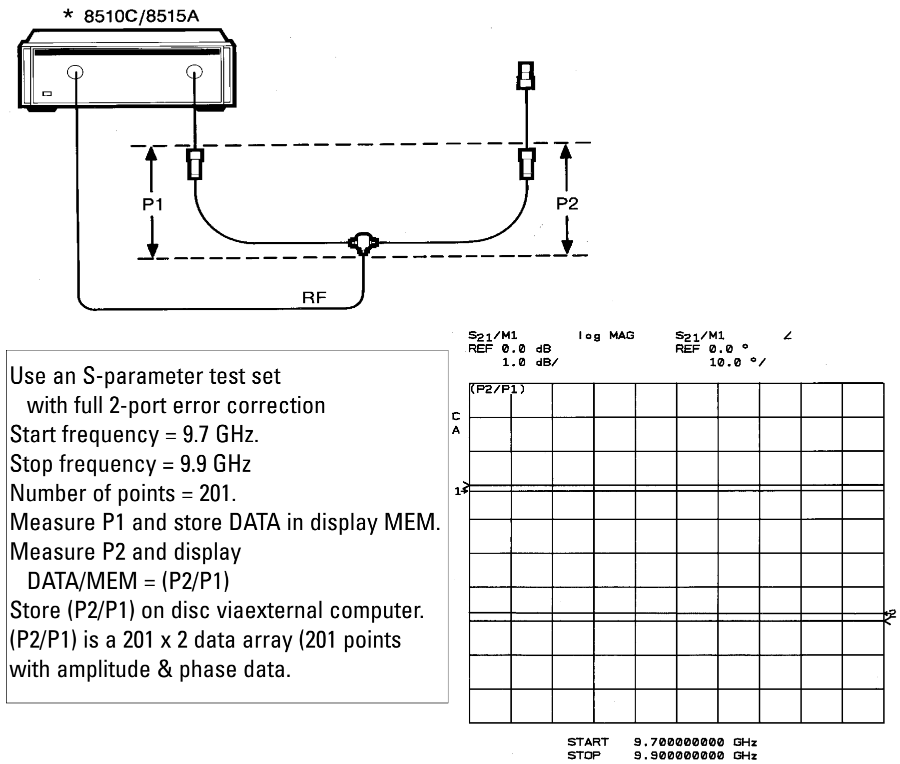


Figure 10. RF power splitter measurement.

Measurement of the 8511A/B channels

The procedure used to measure the difference between the 8511A/B channels (at the IF frequency of 300 MHz) begins by measuring the difference in S21 between the arms of an "IF power splitter". This IF power splitter is used only during the measurement of the 8511A/B channels and will not be used during the actual measurement of the dual-channel receiver.

Also, the IF power splitter arms should interface to the 8511A/B exactly as the IF outputs of the dual-channel receiver will, i.e. they should have the same connector type and geometry.

As shown in *Figure 11*, the difference in S21 between the arms of the IF power splitter (P4/P3) is measured by using full 2-port error connection at the C.W. frequency of 300 MHz. The result (P4/P3) is transferred to an external computer and stored on the disc with the RF power splitter result.

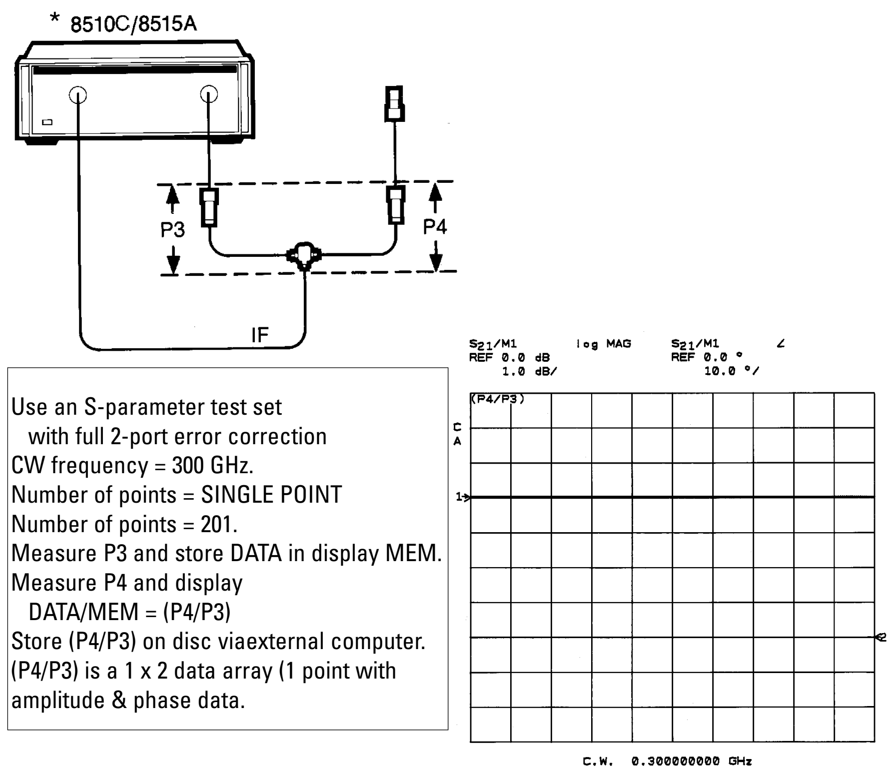


Figure 11. IF power splitter measurement.

***8510C is not shown for simplicity.**

Measurement of the 8511A/B channels (continued)

Next, the IF power splitter is connected to the 8510C and 8511A/B system as shown in Figure 12, and the ratio of the two channels [(b1/a1)=(S2/S1)*(P4/P3)] is measured at the C.W. frequency of 300 MHz. This ratio is then read from the 8510C to an external computer and stored with the RF and IF power splitter results. Note that the 8511A/B channels (S1 & S2) must be measured with any cables and attenuators which will be in place during the actual measurement of the dual-channel receiver. After this measurement of the 8511A/B channels, the IF power splitter is no longer required.

Combining normalization data

Once the results of the RF and IF power splitter measurements and the 8511A/B measurements have been stored in an external computer, they are combined as shown in *Figure 13*. This combined normalization data is then sent to the 8510C and stored in display memory. Once the normalization data has been sent to the 8510C, the external computer is no longer required.

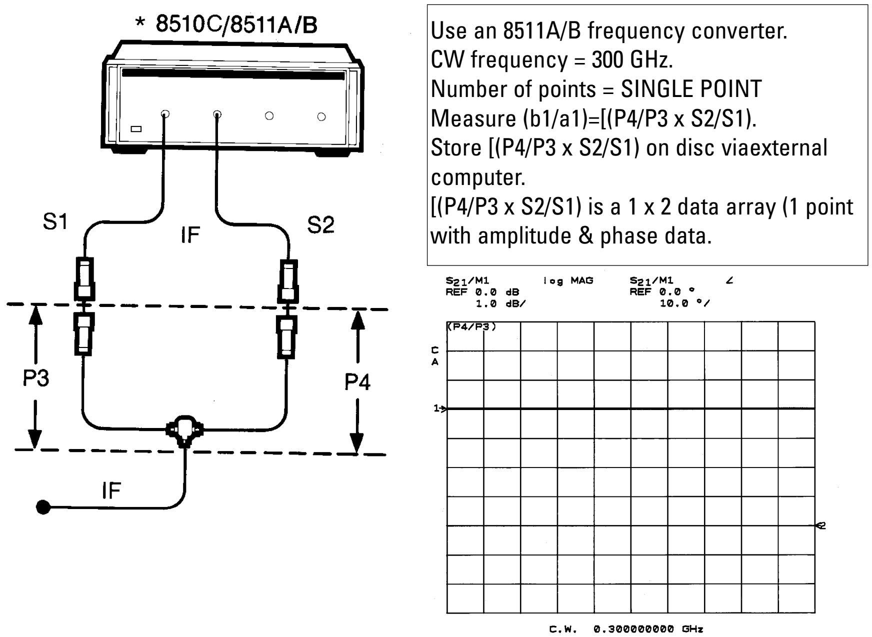


Figure 12. 8511A/B Channel measurement.

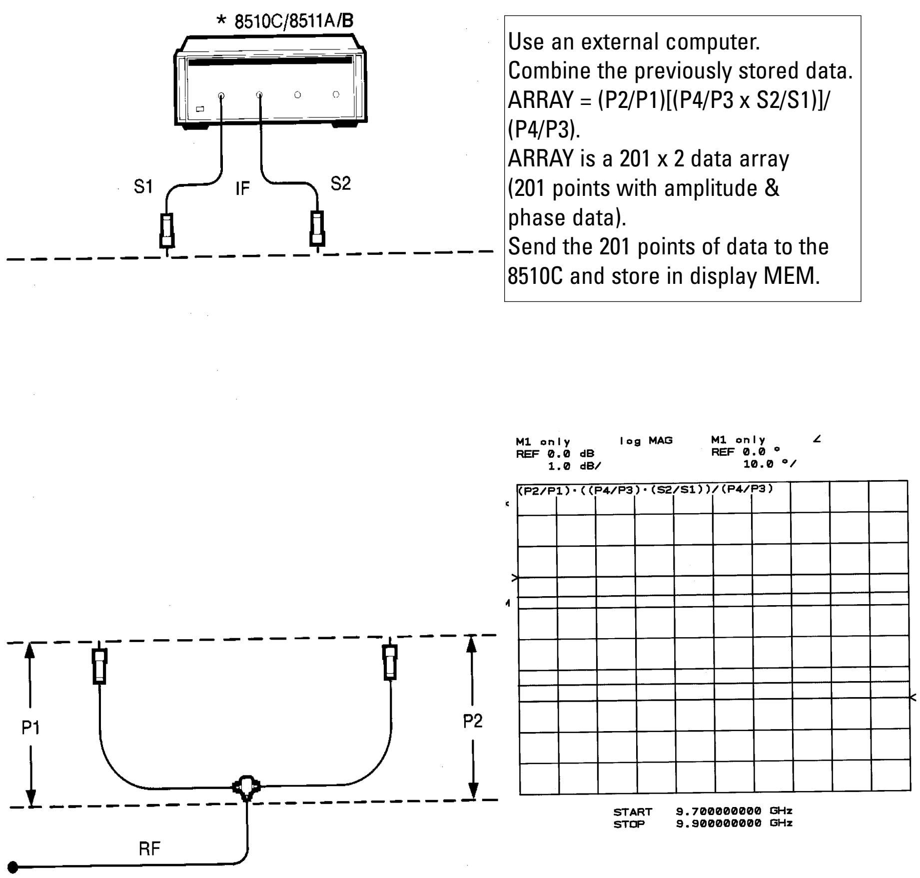


Figure 13. Combining normalization data.

*8510C is not shown for simplicity.

Normalized measurements of dual-channel receivers

Finally, the dual-channel receiver is inserted into the test system (inserted between the RF power splitter and the 8511A/B), multiple source mode is activated (*see Figure 9* for the multiple source definitions), and the ratio of the two channels is measured using the DATA/MEM display mode. As shown in *Figure 14*, the result of this measurement procedure is the amplitude and phase match between the channels of the dual-channel receiver and the effects of the RF power splitter and the 8511A/B receiver channels removed.

Now, if desired, each channel of the dual-channel receiver may be adjusted (or tuned) to improve the match between channels, and the result will be shown on the 8510C display. After one dual-channel receiver has been adjusted satisfactorily, it may be removed so that other dual-channel receivers may be inserted and adjusted in turn.

The measurement procedure described above may be extended to three or four channel receivers by the use of three or four channels of the 8511A/B and two or three 8510C display memories respectively. Also, when measuring two or three channel receivers, it is possible to store the normalization data in an 8510C calibration set and use this calibration set (rather than the display memories) to provide the DATA/MEM display function. This method will free-up all eight display memories for other uses.

Accuracy considerations

As with the measurement of the match between individual FTD components, the measurement of the match between channels of multi-channel receivers has three principal sources of measurement inaccuracy. These sources are, non-ideal system port matches, crosstalk from one channel of the test system to the other, and unwanted mixing products which enter the 8511A/B.

To improve the system port matches, fixed attenuators should be used at the RF power splitter and the 8511A/B as shown in *Figure 8*. Also, the RF power splitter should provide good isolation between channels to reduce system crosstalk. Usually, these multi-channel receivers provide their own internal filtering to eliminate unwanted mixing products. In case they do not have internal filtering,an external bandpass filter centered at the IF and inserted before the 8511A/B will eliminate any unwanted mixing products and their associated spurious responses.

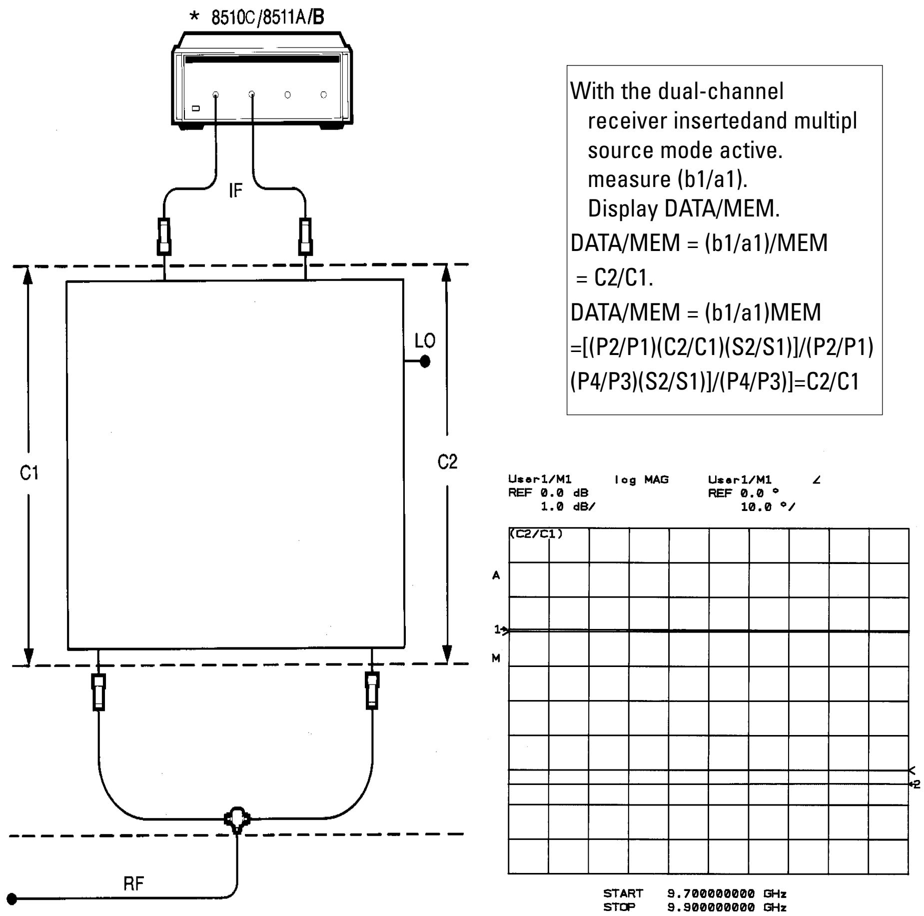


Figure 14. Normalized measurement of dual-channel receiver.

***8510C is not shown for simplicity.**

Appendix A. Spur analysis and avoidance

Spur analysis

To aid in the following analysis, it is assumed that the frequency translation device (FTD) under test is a mixer. (The concept behind this analysis is easily extended to other types of FTDs). As shown in *Figure A1*, the mixer under test has RF and LO inputs and an IF output. In this case, IF=RF-LO. Also emanating from the IF port are several other mixing products of the RF and LO signals. These unwanted mixing products can cause spurious measurement responses; these spurious responses must be avoided or reduced to an insignificant level.

During the measurement of the mixer, the 8510C, which is in multiple source mode, is controlling both the RF and LO sources and the 8511A/B receiver (the IF receiver). As the RF and LO sources are stepped through their frequency ranges, the 8511A/B is stepped through its range of IF=RF-LO. At each measurement point (201, 401, 801, Freq List, etc.), the 8511A/B frequency converter phase-locks onto the incoming IF signal and downconverts it to 20 MHz. This 20 MHz signal continues on, inside the 8510C, and is further downconverted to 100 kHz. The 100 kHz signal is then processed by the 8510C internal computer to extract information about the original IF signal. This information is then displayed on the 8510C screen.

The method used to downconvert the original IF signal to 20 MHz is called sampling. The sampling method presents all the frequency harmonics of the test set voltage tuned oscillator (VTO) to the incoming IF signal. The VTO is pretuned and phase-locked so that one of its harmonics mixed with the incoming IF signal to give exactly 20 MHz. An internal 20 MHz bandpass filter (BPF) stops all other mixing products of the RF, LO, and VTO, which are not at 20 MHz, from continuing on inside the 8510C and causing spurious measurement results.

However, if the incoming IF signal is actually composed of many different frequency components, it is possible that some other component of the IF signal will combine with a different harmonic of the VTO and also produce a signal at 20 MHz. This spurious response will then proceed through the internal 20 MHz BPF, along with the desired signal, and cause a spurious measurement result.

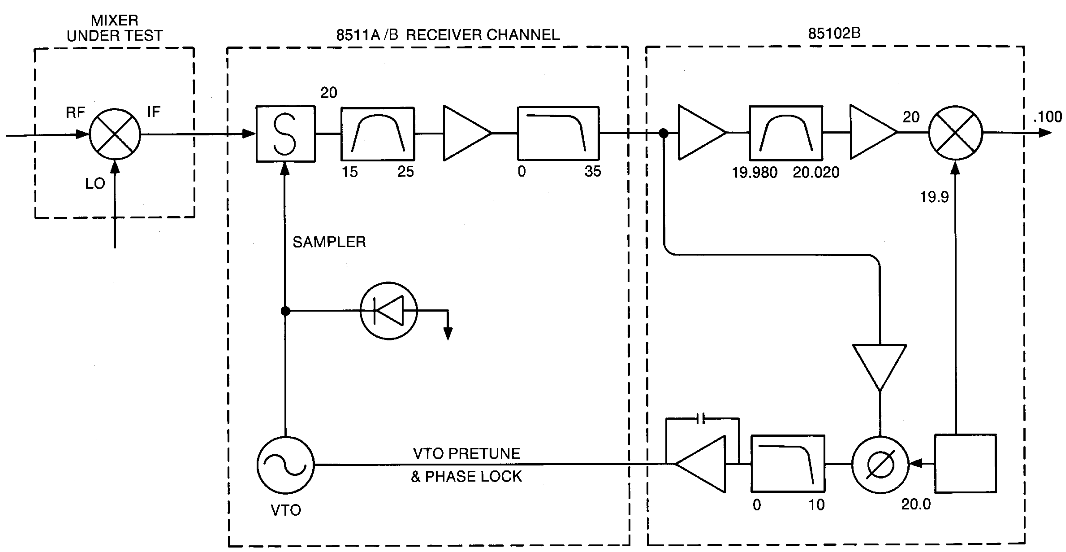


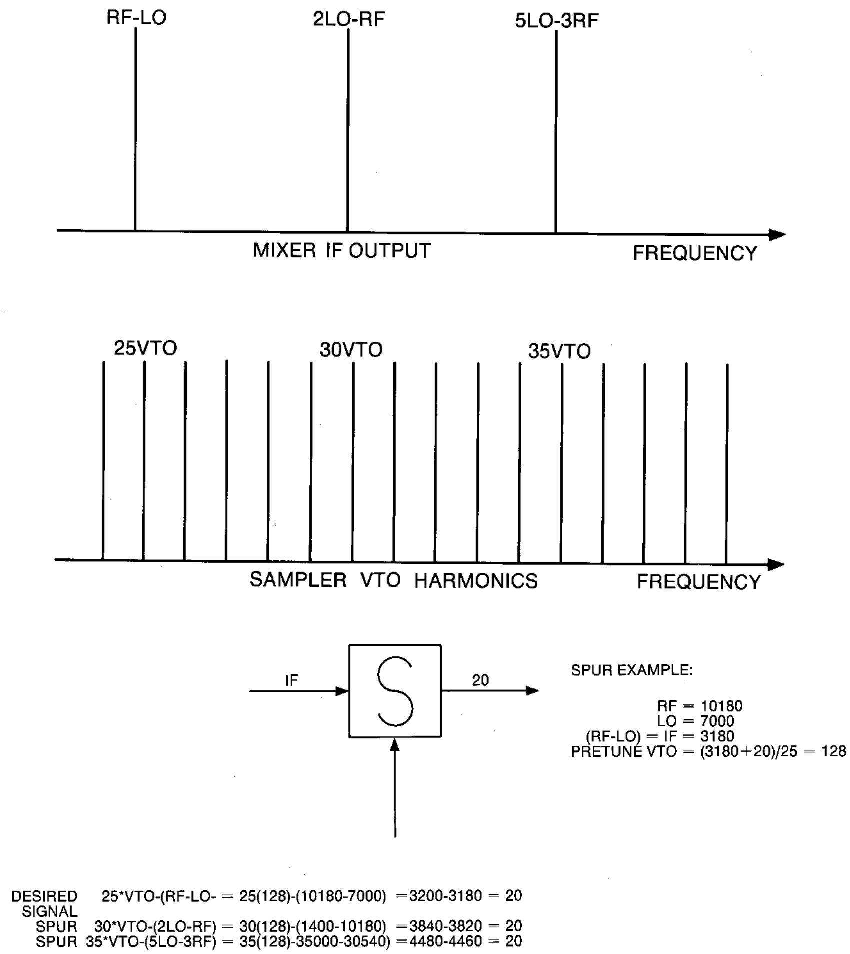
Figure A1. Spur analysis block diagram.

The spur program

The first step toward avoiding or eliminating spurs is to determine at which frequencies they may occur. Included at the end of this appendix is a spur analysis program which can predict the occurrence of spurs for mixer measurements when using the 8510C and 8511A/B-based system shown above. Although the spur program has been specialized for the measurement of downconverting mixers, it can easily be modified for use when measuring upconverters, harmonic mixers, VSWR or mixers, or other frequency translation devices. This program only predicts the possible occurrence of a spur, it does not predict its power level. Also, this program does not consider RF or LO source subharmonics. (If the RF or LO synthesizer is replaced by a sweeper, then the spur program should be modified to account for the sweeper frequency inaccuracy.)

Spur avoidance

As described above, the spur problem stems from unwanted mixing products of the RF and LO signals and the sampling method used in the 8511A/B. The easiest way to eliminate these spurs is to stop the unwanted mixing products of the RF and LO signals from entering the 8511A/B frequency converter. For fixed IF mixer measurements, this is easily accomplished by the use of a BPF centered around the mixer IF signal. This BPF is inserted after the mixer IF port and before the 8511A/B input port. For swept IF measurements, filtering may not work. In this case, it may be necessary to select measurement frequencies, using the 8510C frequency list mode, at which no spurs occur. The spur program may be used to determine at which frequencies there are not spurs. In some cases, a combination of filtering and selectively choosing the measurement frequencies may eliminate any spurious responses.



```
10    ! TSET_SPUR                                                    NMD
20    ! 8510 MIXER SPUR PROGRAM                       REV. 1.0   3/2000   TR
30    OUTPUT KBD;CHR$(255)&CHR$(75);                            ! CLEAR SCREEN
40    INPUT "ENTER RF START FREQ (MHz)",R_start
50    INPUT "ENTER RF STOP FREQ (MHz)",R_stop
60    PRINT USING "2(3A,5D.3D)";"R=",R_start," - ",R_stop
70    INPUT "ENTER LO START FREQ (MHz)",L_start
80    INPUT "ENTER LO STOP FREQ (MHz)",L_stop
90    PRINT USING "2(3A,5D.3D)";"L=",L_start," - ",L_stop
100   INPUT "ENTER NUMBER OF 8510 TRACE POINTS",N_pnts
110   PRINT USING "14A,4D";"NO. OF POINTS=",N_pnts
120   INPUT "ENTER IF FILTER LOWER FREQ EDGE (MHz)",B_start
130   INPUT "ENTER IF FILTER UPPER FREQ EDGE (MHz)",B_stop
140   PRINT USING "13A,6D.3D,1X,3A,4X";"Filter start=",B_start,"MHz","Filter stop
=",B_stop,"MHz"
150   PRINT " "
160   PRINT "    R              L              I            F_vto*  X=    Y         mL -
nR=  Spur"
170   !
180   Mm=1                                                      ! I=(Mm*L+Nn*R)
190   Nn=-1                                                     ! I=( 1*L+-1*R)
200   R_step=(R_stop-R_start)/(N_pnts-1)
210   L_step=(L_stop-L_start)/(N_pnts-1)
220   FOR Pnt=0 TO N_pnts-1
230     R=R_start+Pnt*R_step
240     L=L_start+Pnt*L_step
250     I=ABS(Mm*L+Nn*R)                          ! DETERMINES I
260       CALL Vto(I,V)                           ! DETERMINES Vto FREQUENCY
270     !
280     FOR M=0 TO 10                             ! CONSIDER 0-10 L HARMONIC
290       FOR N=-10 TO 10                         ! CONSIDER 0-10 R HARMONIC
300         IF M=Mm AND N=Nn THEN Necst           ! Mm*L+Nn*R=I, IS NOT SPUR
310         CALL Spur(M,L,N,R,V,B_start,B_stop)   ! DETERMINES SPUR FREQUENCY
320 Necst:NEXT N
330     NEXT M
340   NEXT Pnt
350   END
360   !
370   SUB Vto(I,V)                                  ! V=(8510 Vto FREQUENCY)
380     V=(I+20)/90
390     IF I<20000 THEN V=(I+20)/69
400     IF I<13500 THEN V=(I+20)/47
410     IF I<7000 THEN V=(I+20)/25
420     IF I<2400 THEN V=(I+20)/9
430     IF I<840 THEN V=(I+20)/3
440     IF I<250 THEN V=(I+20)/1
450   SUBEND
460   SUB Spur(M,L,N,R,V,B_start,B_stop)
470     X=ABS(M*L+N*R)
480     IF X<B_start OR X>B_stop THEN Here                 ! IF FILTER SECTION
490     P=X DIV V
500     IF P>(30000/V) THEN Here      !CONSIDER ONLY Vto HARMONICS UP TO 30GHz
510     FOR H=0 TO 1
520       Y=ABS(X-(P+H)*V)
530       IF Y<20.025 AND Y>19.975 THEN       !8510 RECIEVER HAS 50KHz WIDE BPF
540         PRINT USING "3(5D.3D,4X),3D.3D,1A,3D,1A,5D.3D,3X,2D,1A,3D,2A,5D.3D";R
,L,ABS(L-R),V,"*",P+H,"=",V*(P+H),M,"L",N,"R=",X
550       END IF
560     NEXT H
570 Here:SUBEND
```

```
10   ! RECEIVER                                                                    NMD
20   ! 8510 DUAL-CHANNEL RECEIVER MEASUREMENT PROG.     REV. 1.0  3/2000           TR
30   DEG
40   OPTION BASE 1
50   COM Prf(201,2),Prfm(201,2),Prfp(201,2),Ri(201,2)
60   COM Pif(2),Psif(2)
70   ASSIGN @Nwa TO 716
80   ASSIGN @Nwa_data2 TO 716;FORMAT OFF
90   INTEGER Size,Preamble
100 Begin:  !
110   ON KEY 1 LABEL "MEASURE P_RF" GOSUB P_rf
120   ON KEY 2 LABEL "MEASURE P_IF" GOSUB P_if
130   ON KEY 3 LABEL "MEASURE PS_IF" GOSUB Ps_if
140   ON KEY 5 LABEL "COMBINE MEASMNTS" GOSUB Combine
150   ON KEY 6 LABEL "DATA TO 8510 MEM" GOSUB Data_mem
160   ON KEY 8 LABEL "QUIT" GOTO Stp
170 Here:GOTO Here
180 Stp:STOP
190 !****************************************************************************
200 P_rf:! MEASURE RF POWER SPLITTER (P2/P1) & STORE DATA ON DISC
210   DISP "CAL 8510/8515 FOR RF POWER SPLITTER MEAS. - PRESS CONTINUE WHEN READY"
220   PAUSE
230   DISP "MEAS (P2/P1)_RF USING DATA/MEM - PRESS CONTINUE WHEN READY"
240   PAUSE
250   DISP "TAKING DATA - STANDBY"
260   OUTPUT @Nwa;"CHAN1;NUMG1;FORM3;OUTPFORM;" !
270   ENTER @Nwa_data2;Preamble,Size,Prfm(*)    !READ (P2/P1) MAG (dB)
280   OUTPUT @Nwa;"CHAN2;FORM3;OUTPFORM;"       !
290   ENTER @Nwa_data2;Preamble,Size,Prfp(*)    !READ (P2/P1) PHASE
300   OUTPUT @Nwa;"CONT;"
310   FOR P=1 TO 201                            !STORE (P2/P1) DATA IN Prf(*)
320     Prf(P,1)=Prfm(P,1)                      !Prf(P,1)=(P2/P1) MAG (dB)
330     Prf(P,2)=Prfp(P,1)                      !Prf(P,2)=(P2/P1) PHASE
340     PRINT P,Prf(P,1),Prf(P,2)               !PRINT: (P2/P1) 201 POINTS
350   NEXT P
360   INPUT "ENTER FILE NAME TO STORE RF PWR SPLITTER DATA",P_rf$
370   CREATE ASCII P_rf$,32                     !CREATE FILE TO STORE (P2/P1)
380   ASSIGN @File TO P_rf$
390   OUTPUT @File;Preamble,Size,Prf(*);        !STORE (P2/P1) ON DISC
400   DISP "RF PWR SPLITTER DATA STORED IN FILE NAMED - ";P_rf$
410   RETURN
420   !**************************************************************************
430 P_if:  ! MEASURE IF POWER SPLITTER (P4/P3) & STORE DATA ON DISC
440   DISP "CAL 8510/8515 FOR IF POWER SPLITTER MEAS. - PRESS CONTINUE WHEN READY"
450   PAUSE
460   DISP "MEAS (P4/P3)_IF USING DATA/MEM - PRESS CONTINUE WHEN READY"
470   PAUSE
480   DISP "TAKING DATA - STANDBY"
490   OUTPUT @Nwa;"CHAN1;NUMG1;FORM3;OUTPFORM;"
500   ENTER @Nwa_data2;Preamble,Size,Pifm,Useless     ! READ (P4/P3) MAG (dB)
510   OUTPUT @Nwa;"CHAN2;FORM3;OUTPFORM;"
520   ENTER @Nwa_data2;Preamble,Size,Pifp,Useless     ! READ (P4/P3) PHASE
530   OUTPUT @Nwa;"CONT"
540   Pif(1)=Pifm                        !Pif(1)=(P4/P3) MAG (dB)  SINGLE POINT
550   Pif(2)=Pifp                        !Pif(2)=(P4/P3) PHASE     FOR FIXED IF
560   PRINT 1,Pif(1),Pif(2)              !PRINT: (P4/P3) MAG (dB) & PHASE
570   INPUT "ENTER FILE NAME TO STORE IF PWR SPLITTER DATA",P_if$
580   CREATE ASCII P_if$,4               !CREATE FILE TO STORE (P4/P3)
590   ASSIGN @File TO P_if$
600   OUTPUT @File;Pif(*);               !STORE (P4/P3) ON DISC
610   DISP "IF PWR SPLITTER DATA STORED IN FILE NAMED - ";P_if$
620   RETURN
630   !**************************************************************************
640 Ps_if:  ! MEASURE DIFFERENCE IN 8511 CHANNELS & STORE DATA ON DISC
650   DISP "CONFIGURE 8510/8511 SYSTEM FOR RECEIVER TEST - PRESS CONTINUE WHEN READY"
```

```
670   DISP "MEAS [(P4/P3)_IF]*[(S2/S1)_IF] USING DATA/MEM - PRESS CONTINUE WHEN R
EADY"
680   PAUSE
690   OUTPUT @Nwa;"CHAN1;NUMG1;FORM3;OUTPFORM;"
700   ENTER @Nwa_data2;Preamble,Size,Psifm,Useless !READ [(P4/P3)*(S2/S1)] MAG
710   OUTPUT @Nwa;"CHAN2;FORM3;OUTPFORM;"
720   ENTER @Nwa_data2;Preamble,Size,Psifp,Useless !READ [(P4/P3)*(S2/S1)] PHASE
730   OUTPUT @Nwa;"CONT;"
740   Psif(1)=Psifm          !Psif(1)=[(P4/P3)*(S2/S1)] MAG (dB)   SINGLE POINT
750   Psif(2)=Psifp          !Psif(2)=[(P4/P3)*(S2/S1)] PHASE      FOR FIXED IF
760   PRINT 1,Psif(1),Psif(2) !PRINT:  [(P4/P3)*(S2/S1)] MAG (dB) & PHASE
770   INPUT "ENTER FILE NAME TO STORE IF PWR SPLITTER/RECEIVER DATA",Ps_if$
780   CREATE ASCII Ps_if$,4   !CREATE FILE TO STORE [(P4/P3)*(S2/S1)]
790   ASSIGN @File TO Ps_if$
800   OUTPUT @File;Psif(*);   !STORE [(P4/P3)*(S2/S1)] ON DISC
810   DISP "IF PWR SPLITTER/RECEIVER DATA STORED IN FILE NAMED - ";Ps_if$
820   RETURN
830   !*********************************************************************
840 Combine:   ! COMBINE NORMALIZATION DATA
850   DISP "STANDBY TO COMBINE NROMALIZTAION DATA - PRESS CONTINUE WHEN READY"
860   PAUSE
870   INPUT "ENTER RF PWR SPLITTER DATA FILE NAME",P_rf$
880   DISP "LOADING RF PWR SPLITTER DATA - STANDBY"
890   ASSIGN @File TO P_rf$
900   ENTER @File;Preamble,Size,Prf(*)                    !READ (P2/P1) 201 POINTS
910   INPUT "ENTER IF PWR SPLITTER DATA FILE NAME",P_if$
920   ASSIGN @File TO P_if$
930   ENTER @File;Pif(*)                                 !READ (P4/P3) SINGLE POINT
940   INPUT "ENTER IF PWR SPLITTER/RECEIVER DATA FILE NAME",Ps_if$
950   ASSIGN @File TO Ps_if$
960   ENTER @File;Psif(*)                      !READ [(P4/P3*(S2/S1)] SINGLE POINT
970   DISP "COBINING NORMALIZATION DATA - STANDBY"
980   WAIT 2
990   FOR P=1 TO 201  !FOR ALL 201 MEASUREMENT POINTS COMBINE NORMALIZATION DATA
1000    M=10^(.05*(Prf(P,1)+Psif(1)-Pif(1))) !COMBINE MAGNITUDE DATA
1010    Ph=Prf(P,2)+Psif(2)-Pif(2)           !COMBINE PHASE DATA
1020    Ri(P,1)=M*COS(Ph)           !PUT NORMALIZATION DATA IN REAL AND IMAGINARY
1030    Ri(P,2)=M*SIN(Ph)           !FOR EASY INPUT INTO 8510C DISPLAY MEMORY
1040  NEXT P
1041  !BECAUSE THE MEASUREMENT SYSTEM USES FIXED ATTENUATORS TO PROVIDE GOOD
1042  !SOURCE AND LOAD MATCH TO THE DUT THE ABOVE COMBINATION OF THE
1043  !NORMALIZATION DATA IS VALID.  OTHERWISE WE WOULD HAVE TO USE TRUE
1044  !VECTOR MATH TO ACHIEVE ERROR CORRECTION, AND VECTOR MATH THROUGH
1045  !FREQUENCY TRANSLATION DEVICES IS MEANINGLESS.
1050  INPUT "ENTER FILE NAME TO STORE NORMALIZATION DATA",Ri$
1060  CREATE ASCII Ri$,32             !CREATE FILE TO STORE NORMALIZATION DATA
1070  ASSIGN @File TO Ri$
1080  OUTPUT @File;Preamble,Size,Ri(*); !STORE NORMALIZATION DATA
1090  DISP "NORMALIZATION DATA STORED IN FILE NAMED - ";Ri$
1100  RETURN
1110  !*********************************************************************
1120 Data_mem:  !TRANSFER NORMALIZATION DATA BACK TO 8510  DISPLAY MEMORY
1130  INPUT "ENTER NAME OF FILE WHICH CONTAINS DATA FOR 8510 MEM",Ri$
1140  ASSIGN @File TO Ri$
1150  DISP "ENTERING DATA FROM COMPUTER MEMORY - STANDBY"
1160  ENTER @File;Preamble,Size,Ri(*)
1170  DISP "ENTERING DATA INTO 8510 DISPLAY MEMORY - STANDBY"
1180  OUTPUT @Nwa;"HOLD;CHAN1;FORM3;INPUDATA;"
1190  OUTPUT @Nwa_data2;Preamble,Size,Ri(*)
1200  OUTPUT @Nwa;"CHAN2;FORM3;INPUDATA;"
1210  OUTPUT @Nwa_data2;Preamble,Size,Ri(*)
1220  OUTPUT @Nwa;"CHAN1;DATI;DISPMATH;"
1230  OUTPUT @Nwa;"CHAN2;DATI;DISPMATH;CONT;"
1240  DISP "MEMORY TRANSFER COMPLETE - BEGIN RECEIVER MEASUREMENTS"
1250  RETURN
1260  !*********************************************************************
1270  END
```

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